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A MODEL FOR CALCULATION OF UNDULATORY DEFORMATION OF SHEET GLASS IN LATERAL HARDENING

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A method for calculating undulatory deformation of sheet glass moving in a heating furnace is refined. It is established that the standard calculation method applied to a multi-support scheme produces an approximately double error in estimating the deformation.

Some attempts were previously undertaken [1] to analytically describe undulatory deformation of sheet glass as it is transported on a roll conveyor of a horizontal heating furnace. Calculations were based on the method of N. V. Solomin [2], according to which the temporary deformation of an article for any type of loading and a preset temperature t is described by the formula

$$y(\tau) = S\omega,$$

where τ is the deformation duration; S is the transition modulus; ω is the elastic deformation under the same loading conditions.

The proposed paper is the result of studying the relationship between the parameter ω and the article size and design parameters of the heating furnace.

In the considered case, the elastic deformation ω for a glass sheet of length L, width B, and thickness d is the deflection by gravity of a beam which is resting on a certain number of intermediate supports n, whereas

$$N = L/l,$$

where l is the roll conveyor step.

It is clear that the value n cannot be a fractional number; for the actual sizes of mass-produced articles (car glass) and average step of the rolls $l = 100$, $n = 3, 4, 5, 6$ and higher.

The estimated model of elastic deformation used previously [1] implied a two-support scheme ($n = 2$), which led to the result known in the theory of strength of materials [3]:

$$EI\omega^{\max} = \frac{5}{384} ql^4, \tag{1}$$

where E is the elasticity modulus for a given temperature; I is the axial moment of inertia of the beam lateral section; q is the specific linear load caused by gravity.

In this case,

$$I = \frac{Bd^3}{12};$$

$$q = Bd\rho g, \tag{2}$$

where ρ is the glass density; g is the free fall acceleration.

Equation (1) can be represented in the form of a dimensionless deformation index for the two-support loading scheme:

$$Ind_2 = \frac{EI\omega^{\max}}{ql^4} = \frac{5}{384}.$$

The main purpose of the present paper was to investigate the effect of the parameter on the absolute value of the deformation index.

For this purpose, the model of deformation of an uncut beam (Fig. 1) resting on n supports and loaded with a constant load q according to Eq. (2) was used. This problem can

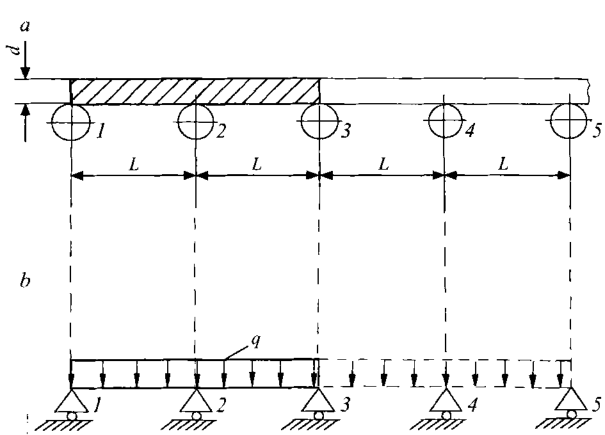

Fig. 1. Position of glass on the rolls (a) and the calculation scheme (b): $1 - 5$) sequence numbers of supports.

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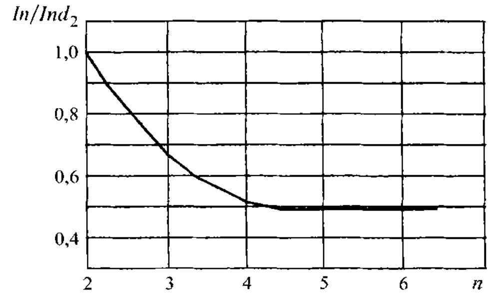

Fig. 2 Dependence of relative deformation of glass on the number of supports.

be solved for different numbers of supports using what is known as the equation of three moments [3] with subsequent construction of curves for the lateral forces, the bending moments, and the deflection, whereas the maximum deflection was taken from the latter curve, regardless of the span or the point where this maximum deflection occurred.

The results of the analytical solution are shown in Fig. 2. The ratio of the deformation index for the n-support loading scheme to the same index for the two-support loading scheme is indicated on the vertical axis of the diagram. It is found that as the number of supports decreases, this ratio keeps decreasing from 1 to 0.49 and is virtually equalized at $n \geq 5$.

The established fact indicates that the two-support scheme used previously resulted in an approximately double overestimation of undulatory deformation.

The proposed variant calculation contributes to getting a refined prediction of the absolute deformation of sheet glass moving on a roll conveyor of a hardening furnace, which in future will make it possible to prescribed more justified technology parameters for glass hardening.

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